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History versus Expectations: an Empirical Investigation

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HISTORY VERSUS EXPECTATIONS: AN EMPIRICAL INVESTIGATION [1]

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Abstract

This paper provides the first empirical test of the role of history versus expectations in U.S. urban development. Starting from Paul Krugman's theoretical work in new economic geography, we test whether or not a modern city develops because of either advantageous initial conditions or by way of a self-fulfilling prophecy based on expectations of development. Using the methodology developed by Granger to establish causality between two variables, but adapted to a cross-section with four time lags, we test whether asset values, that is, farmland values and housing values, anticipate urban development or vice versa. In the case of the former, we would conclude that expectations drive urban development in the U.S., and in the case of the latter we would conclude that history does. The results indicate very strongly that initial conditions, that is history, dominate the process by which one city becomes a metropolis and another languishes in the periphery.

JEL Classification Codes: R11, F00.
Keywords: History vs. expectations, urban growth, Granger causality, economic geography.

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1 Introduction

This paper is motivated by the recent revival of interest in economic geography. A key issue addressed by this literature is how clusters of economic activity organize within a finite space. Questions concerning the location of economic activity, how we understand the contrast between dense urban areas and desolate rural hinterlands, why one small town develops into a metropolis while another languishes, are all attracting increasing attention. The technically demanding nature of new economic geography has been eased by the adoption of the Dixit-Stiglitz model of monopolistic competition in much new literature [Fujita, Krugman, and Venables (1999)]. One of the most interesting questions to come out of this revitalization of economic geography, the relative importance of history versus expectations in determining which cities will become the industrial core of a region, is the focus of this paper.

One might naturally presume that the city to first establish itself as a center of industrialization would dominate in a model with increasing returns. However, if people expect one city to dominate relative to others, then as labor and capital move into that city it will become the core by means of a self fulfilling prophecy. Both of these forces exist to some degree within the spatial economy and in determining a regional economic hierarchy between cities. But as of yet, there is no empirical evidence as to which of the two dominates as cities develop. Krugman (1991a, b) uses a model of trade with external economies and adjustment costs to explore history versus expectations in determining economic outcomes between regions.[2] He notes that there is good reason to suspect that, at least for large economic units, history is of much greater importance in determining a spatial economic hierarchy. Capital and labor mobility has simply never been high enough to allow for expectations alone to determine the rise and fall of whole economic regions. For smaller economic entities like cities within a country, where capital and labor are very mobile, it seems fully plausible that expectations could take a leading role in determining urban development. Fukao and Benabou (1993) corrected the part of Krugman's model governing the dynamic behavior of the labor force and in the process refined its predictive power, as we see below.

Despite the theoretical revitalization, there has been little empirical work aimed at testing

[2]See also Matsuyama (1991), who explores similar issues in the context of industrialization, and Baldwin (1999) and Gali (1995) for more recent contributions.

important propositions of economic geography. Notable exceptions include Black and Henderson (1999), Hanson (1998), Thomas (1996), Dobkins and Ioannides (1998; 2000), and Ioannides and Overman (1999). Hanson and Thomas both use Krugman (1991a) as a starting point but modify the model to allow for diseconomies from congestion and to develop an estimable model. Dobkins and Ioannides (1998) for their part find strong evidence of spatial clustering that is nonlinearly related to size and further strengthen the idea that spatial considerations are important in urban growth. Ioannides and Overman (1999) contrast non-parametric with parametric techniques and explore a spatial version of Zipf's Law. While these works mark important empirical forays into economic geography in general, there has not yet been any empirical work exploring the relative roles of history versus expectations as determinants of urban development. This paper seeks to fill that gap by developing an empirical basis for history versus expectations and providing evidence for the relative importance of the two forces in urban development.

The following section reviews the framework developed by Krugman (1991a, b) concerning the development of a core city and proposes an asset pricing model that will allow us to separate the effects of history and expectations. This framework and model will serve as our basis for evaluating the forces that lead cities to develop. Section 3 discusses the data set used for this paper. Section 4 discusses the econometric techniques we use to test whether it is history or expectations that is the primary force of urban spatial development. Section 5 presents the results and conclusions.

2 Theoretical Background: Krugman's Model

We start by presenting the key elements of a model, due to Krugman (1991a, b) where external economies and adjustments combine to determine the relative importance of history versus expectations in shaping equilibrium. Krugman (1991a) applies the model in an economy with a single factor of production and two regions, while Krugman (1991b) applies it to an economy with two sectors. We follow the two-region version, where we understand regions as alternative sites for urban development. External economies are modeled indirectly by assuming that the differences between the real wage rates in site 1 and site 2, ω_1 and ω_2 respectively, is increasing in the share of the total labor force that is located in site 1,

$$\omega_1 - \omega_2 = \alpha(L_1 - \bar{L}), \tag{1}$$

where $\bar{L}$ denotes the value for the labor force in site 1 that equates real wages in the two sites and α is a positive parameter. Let σ denote the value associated with being in site 1 instead of site 2. Under the assumption of perfect capital markets and a constant instantaneous rate of interest r, this value is "priced" as an asset according to $\dot{\sigma} = r\sigma - (\omega_1 - \omega_2)$, which by using (1) becomes:

$$\dot{\sigma} = r\sigma - \alpha(L_1 - \bar{L}). \tag{2}$$

The costs of labor migration are assumed to be quadratic in $\dot{L}_1$, the rate of the labor force change in site 1, $\frac{1}{2\gamma}(\dot{L}_1)^2$. If the present value of the future stream of wages in each site differ, workers seeking to maximize the benefit from moving would equate the marginal cost of moving to site 1, $\frac{1}{\gamma}\dot{L}_1$, to the marginal benefit from moving, σ. That is:

$$\dot{L}_1 = \gamma\sigma. \tag{3}$$

Differential equations (2) and (3) define a dynamical system in (L_1, σ). This system admits a steady state, $(L_1^* = \bar{L}, \sigma^* = 0)$. As Krugman shows, in the vicinity of the steady state, the system is unstable. If $r^2 - 4\alpha\gamma \geq 0$, then both roots of the system are real and positive, so that the linearized system steadily diverges from the steady state. Here, the labor force concentrates in whatever city started out with more workers. The only role of expectations is to reinforce the role of history. If, on the other hand, $r^2 - 4\alpha\gamma < 0$, then the roots are complex and have a positive real part, and the linearized system diverges from the steady state in expanding oscillations. In this case, if $L_1(0)$ lies within a certain range, referred to by Krugman as the "overlap," there will be a multiplicity of self-fulfilling equilibrium paths. Fukao and Benabou (1993) corrected some of Krugman's results and in the process also clarified its empirical implications. As they show, it is necessary to conduct an analysis of the *global* behavior of the Krugman model. If the economy starts outside the steady state it will hit a boundary $L_1 = 0$, or $L_1 = 1$, in *finite* time. Fukao and Benabou show that the width of the overlap is $\exp\left[-r\pi(4\alpha\gamma - r^2)^{-\frac{1}{2}}\right]$. Unless one wishes to take the Krugman's model literally, its basic conclusions may be interpreted broadly as suggesting that the more impatient agents are the higher the rate of interest r and the higher the strength of the external economy relative to adjustment costs, $\alpha\sigma$, the more likely it is that the system would diverge in a monotone fashion from the steady state. If, on the other hand, agents are very patient and/or adjustment costs and the intensity of the external economy are large, then the overlap is wide.

Krugman's model illustrates that theory by no means precludes a significant role for expectations in determining an urban hierarchy on a grand role and particularly not when it comes to smaller-scale events such as the development of a given city. The attractiveness of his model is that it describes a system where different sets of parameter values lead to different outcomes. When it comes to history versus expectations, what is true in one city may not be true in another. Krugman notes, however, that his own a priori expectation would be that history rules and expectations at best play a supporting role.

2.1 Asset Prices and Future Development

In our adaptation of the Krugman model, we invoke some important features of urban development. First, successful sites for urban development are often associated with superior access to transportation, geography, natural or agricultural resources. Urban development is often associated with speculative economic activity in the market for land and housing, which may either follow urban development or precede it. In order to empirically evaluate the role of history versus expectations we combine Krugman's theory on the behavior of labor with asset pricing in the presence of housing and land. One of the important assumptions from Krugman's approach and one which we will adopt is that labor is forward looking and able to calculate the present value of wages it receives over time in any given city. However, in order to empirically evaluate Krugman's theory, we need to consider how expectations of future development affect current asset values.

We eschew development of a full model and instead borrow some basic results from Englund and Ioannides (1993), who develop a model of housing prices where individuals may also hold land, bonds, and productive capital in their portfolios. The price of land at time t, $q(t)$, is the expected value of rents on that land in time $t+1$, $R(t+1)$, plus the price of land at time $t+1$, $q(t+1)$, discounted by the market rate of interest. By adapting to continuous time, we have:

$$\dot{q}(t) = rq(t) + R(t). \tag{4}$$

Housing values similarly obey an asset equilibrium condition where the current value of a house, $x(t)$, is equal to the expected value of the rents to be earned in time $t+1$, $\rho(t+1)$, plus the value of the house at time $t+1$, $x(t+1)$, multiplied by a depreciation rate $1-\delta$, with the sum multiplied by the discount factor. That is, again by adapting to continuous time, we have:

$$\dot{x}(t) = (r - \delta)x(t) + \rho(t). \tag{5}$$

These asset equilibrium conditions provide a basis for studying the role of expectations in determining why one city becomes dominant relative to another. If individuals expect city 1 to dominate relative to city 2, based on a greater present value of future wages, then asset prices associated with city 1 should increase in anticipation of future development. This follows by solving forward equations (4) and (5). Current housing values and land values will be bid up accordingly as residents of city 1 raise their expectations of the future value of land, housing, and rent. This relationship allows us to observe whether or not expectations play a role in determining which cities dominate because if expectations are at work we should observe asset prices anticipate urban development. If, on the other hand, we observe that assets lag behind urban development then we can conclude that expectations are not a significant factor and that initial conditions rule. While housing values are generally observed, it is difficult to find data on urban land values, especially historical ones. The availability of data on farmland values provides an opportunity, albeit indirect, to make up in part for the lack of urban land values. A standard Alonso-Mills-Math model of the urban structure relates urban land values to the opportunity cost of land at the edge of the city. Typically, emergence of a city is explained because of the ability of the urban economy to bid land away from agriculture and into urban land use. Similarly, one would expect that anticipation of the development of land would also bid up its price.

It is interesting to explore analytically the inter-relationships between all observable variables by means of a simple model. Let us assume that the typical individual's utility function is Cobb-Douglas with housing consumption, food consumption and other consumption as its arguments, and its housing consumption exponent is given, $0 < \beta < 1$. It follows that housing expenditure satisfies

$$R(z)C_h(z) = \beta(y - (\tau(z)), \tag{6}$$

where z denotes distance from the CBD, $R(z)$ the rental rate per unit of housing, that is, land, $C_h(z)$ housing consumption in units of land, y income per person, and $\tau(z)$ money cost of transportation to and from the CBD. Assuming a linear city configuration, locational equilibrium implies that:

$$R(z) = R_a \left(\frac{y - \tau(z)}{y - \tau(\bar{z})} \right)^{\frac{1}{\beta}}, \tag{7}$$

where $\bar{z}$ denotes the size of the linear city and R_a, the land rental in agriculture. By using (6) (7) and imposing equilibrium in the housing (land) market, we have that city population is given by $P = 2\int_0^{\bar{z}} \frac{dz}{C_h(z)}$, which allows us to write

$$1 - \frac{\bar{\tau}\bar{z}}{y} = \left(1 + \frac{\bar{\tau}}{2R_a} P\right)^{-\beta}, \tag{8}$$

where we have assumed that commuting costs are linear: $\tau(z) \equiv \bar{\tau}\bar{z}$. By applying (8) in (7) for $z = 0$, the land rental at the CBD satisfies:

$$R(0) = R_a + \frac{\bar{\tau}}{2} P. \tag{9}$$

Therefore, anticipation of population size is reflected in the excess of the land rental at the CBD over the city's edge. While the specific implications of this model need not be taken too seriously, a relationship like (9) would typically survive in more complicated models. Furthermore, the bid-rent interpretation of the model allows us to reverse its logic and conclude that anticipation of development would bid up the price of agricultural land as well.

3 Data

The data set is the same as the one used by Harris and Ioannides (2000). It is put together from Census data,[3] Unfortunately, land price data on a large number of metropolitan areas over time is very hard to come by, and we finally settled for an index of farm real estate values for the contiguous 48 U.S. states. The index was based on data received from the Farm Report surveys conducted each year by the U.S. Department of Agriculture, and is continuous for the years 1912 to 1989, when it was discontinued. This index was converted into real dollar values using a similar survey conducted by the Census of Agriculture, which could not be used instead of the index because

[3] The data come from a number of Bureau of the Census for the 1950 - 1980 censuses, that are available as ICPSR studies. See the references on United States Department of Commerce sources. We follow roughly the same principles as those employed by Dobkins and Ioannides (2000), but include several additional variables, such as farmland prices and housing values. The 1990 data come from the CensusCD.

it did not completely cover our timeline of interest.[4] These series on state farmland values were published in the periodical *Farm Real Estate Market Developments: Outlook & Situation* by the United States Department of Agriculture. Although the farm lands data is state data, regressions that included the variable were still run at the metropolitan area level. Instead of creating state averages of the other statistics, we simply assigned the same farm land value to each metropolitan area in a given state at time t.[5] This is not as unrealistic as it sounds when one considers that major cities are often served agriculturally by the same hinterlands, particularly when they are major cities in the same state. Only 161 cities, 160 when dealing with farmland prices, could be used. Given the methodology we develop in the next section, only those cities counted by each and every one of the five censuses between 1950 and 1990 could be used. While this eliminates about half of the total number of cities we have data on, the ones left are generally speaking the largest, the oldest, and the most important 161 cities. We feel that altering the methodology to incorporate the other smaller cities would make our results less robust than if we just eliminated the cities that are not defined for the regressions we want to run.

4 Econometric Approach

The technique we use to observe whether it is expectations or history which determines urban development is based on the tests for causality introduced by Granger (1969) and Sims (1972). The test was originally designed to establish causality for time series data and was easily adapted for our purposes. The adaptation works because in order to establish the relative importance of history and expectations we have to ask the same types of questions that are needed to establish causality. As the behavior of labor and the asset equilibrium condition imply, if expectations determine the core and periphery structure, then asset values must anticipate population, our measure of urban development. If land prices were to anticipate development in such a manner, then it would be clear that the inhabitants expect the city to develop in the future and that that expectation is, in fact, helping to drive growth. The question "Do asset prices anticipate population?" is answered

[4] However, only the base year is needed to convert from the index to dollar values.

[5] For metropolitan areas that extend over two or more states, such as New York City, the primary state alone is used.

by running the following time series regressions:

$$p_{it} = c + \sum_{m=1}^{4} \zeta_m^p p_{i,t-m} + \sum_{m=1}^{4} \zeta_m^q q_{i,t-m} + \epsilon_{it}, \tag{10}$$

$$p_{it} = c + \sum_{m=1}^{4} \eta_m p_{i,t-m} + \varepsilon_{it}, \tag{11}$$

where q_{it} is the value of an asset (housing or land) and p_{it} is population in city i at time $t = 1990$. If land prices do anticipate population (development) then their presence in equation (10) should significantly contribute to the explanatory power of regression (11). We use a standard $F-$test to decide whether the group of coefficients $\zeta_1^q, \zeta_2^q, \zeta_3^q, \zeta_4^q$ are significantly different from zero. If they are, then we reject the null hypothesis that "asset prices do not anticipate population." However, in order to firmly establish that asset values anticipate development, we must concurrently show that population does not anticipate asset prices. If population anticipates asset values and asset values also appear to anticipate population, then it is likely that one or more other variables are driving these changes and our test has proved inconclusive. Thus, we also test the null hypothesis "population does not anticipate asset prices" by running the same regressions as above, but switching the population and the asset price variables. In other words we test,

$$q_{it} = c + \sum_{m=1}^{4} \theta_m^q q_{i,t-m} + \sum_{m=1}^{4} \theta_m^p p_{i,t-m} + \epsilon'_{it}, \tag{12}$$

$$q_{it} = a + \sum_{m=1}^{4} \theta_m q_{i,t-m} + \varepsilon'_{it}, \tag{13}$$

If we do not reject the null hypothesis that "population does not anticipate asset prices," then this would confirm earlier results indicating that asset prices do anticipate population. If we reject this null hypothesis as well as the earlier null hypothesis, then this indicates a problem with our specification. Similarly, if both null hypotheses were not rejected, this too would likely indicate a misspecification.

The breadth of our data set allows us to use information on three different types of assets that would indicate an important role for expectations: farm land prices, median housing values, and median gross rents. Land and housing as assets are represented in the asset equilibrium condition, and all three incorporate the expectations of the city inhabitants. Housing rents may be used to infer the asset value of housing by solving (5) forward. By running the Granger causality regressions with each of these assets we hope to establish consistency in our findings. After running the Granger regressions with each of the three different assets, we then run them all again while including the first through fourth lags of population density. One would expect density to contribute significantly to explaining population and asset prices, making it important to control for density in order to accurately establish the relationship between population and asset prices. The brief theoretical analysis presented above suggests that asset values would be affects by contemporaneous population, through the size of the city. We repeat these regressions by including contemporaneous population.

5 Results and Concluding Remarks

The Granger causality tests, regardless of which asset was used to represent expectations or whether density was controlled for or not, all indicated that history is the determining factor in the successful development of a core city. For each of the three different assets, history was significant at the 5% level generally and at the 1% level when we controlled for density. The results confirm the notion that expectations at best help history along in determining whether a city dominates or languishes in the periphery.

Table 1 summarizes the first Granger causality couplet, where we seek to determine whether population anticipates farmland prices or, conversely, whether farmland prices anticipate population. The first regression is of real farmland prices on the first four lags of real farmland prices and the first four lags of population. The corresponding F-test on the lags of population indicates that the addition of the first four lags of population contributed significantly (5% level) in explaining the movements in land prices. This means that population anticipates real farmland prices, and that there is effectively a causal relationship.

The results of regression 2 fulfills the second condition needed to establish causality by showing that real farm land prices do not anticipates population. This second regression is of population on the first four lags of population and the first four lags of real farmland prices. A corresponding F-test on the lags of farmland prices shows that the addition of farm price lags does not significantly contribute to explaining the movements in population over time. Thus, farmland prices do not anticipates population. The results of regressions 1 and 2 are evidence of the importance of initial conditions because they show that expectations do not play a significant role in determining a city's future development. The theory developed above illustrated that if expectations drive development by way of a self-fulfilling prophecy, then asset prices would anticipates population as expectations of future development were incorporated into asset prices. The results of our first pair of Granger causality regressions, however, clearly show that farmland prices do not anticipate population, but rather population anticipates farmland prices. This indicates that asset prices are not accurately predicting future development and thus that expectations do not play a major role in determining the urban hierarchy. The conclusion then is that initial conditions are the primary motivating force behind the establishment of a core city, where any advantage one city has over another that leads to higher real wages will be exploited as labor moves from the lower-wage city to the higher-wage city spurring development and designating the higher-wage city as the core.

Table 2 runs the same two regressions and F-tests described above except that the first four lags of density are now also included. The results are exactly the same except that they are stronger, with the four lags of population being jointly significant at the 1% level as opposed to the 5% level in explaining future movements in farm land prices. Similarly, the first four lags of real farmland prices were even less jointly significant in explaining future movements of population.

Tables 3 and 4 and Tables 5 and 6 are the same regressions as in Tables 1 and 2, except that real farm land prices were replaced with real median housing values and real median gross rents respectively. In all cases the results are exactly the same as in the first four regressions: population anticipates asset values and asset values do not anticipates population, regardless of what asset is used. This relationship becomes even stronger when we control for density with the four lags of population becoming significant at the 1% level in explaining the given asset value. The consistency of these results using different asset values provides further evidence of the dominating role of initial conditions in determining the core development of a city and the overall absence of expectations.

Finally, we repeat the above regressions while allowing for the presence of contemporaneous population. Overall, our conclusions change very little. Specifically, when real farm values are the asset, the results are weakened by remaining significant at only when we control for density and at the 5% level, However, when median housing values are used, the results are strengthened by becoming significant at 1% even when the density is not included. The results with rents are unaffected.

In interpreting these results, however, it is important to note that they do not completely exclude expectations from deciding whether a given city will develop strongly. The regressions are based on a cross-section of 161 different cities with retrospective information, and the results indicate simply that history rules and expectations at best helps history along. These results say nothing of any one city in particular and in that sense we have defined a stereotype that in general may be true but does not necessarily hold for any particular city. Thus, a natural next step in the empirical study of history versus expectations would be to gather more extensive time series data for these cities, including annual asset price data and population data, and to use the Granger causality methodology to evaluate the experience for each individual city.

While this paper has established the general dominance of history, longer time series analysis of individual cities and with observations obtained at more frequent intervals would illustrate for which cities in particular expectations played a primary role in their development, if any. Such research would further help define the relationship between the importance of initial conditions and the power of expectations.

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APPENDIX A

List of Metropolitan Areas (MAs) Included

Akron, OH PMSA. Albany–Schenectady–Troy, NY MSA. Albuquerque, NM MSA. Allentown–Bethlehem–Easton, PA–NJ MSA. Altoona, PA MSA. Amarillo, TX MSA. Asheville, NC MSA. Atlanta, GA MSA. Atlantic City, NJ MSA. Augusta, GA–SC MSA. Austin, TX MSA. Baltimore, MD MSA. Baton Rouge, LA MSA. Beaumont–Port Arthur, TX MSA. Binghampton, NY MSA. Birmingham, AL MSA. Boston, MA PMSA. Bridgeport-Milford, CT PMSA. Brockton, MA PMSA. Buffalo, NY PMSA. Canton, OH MSA. Cedar Rapids, IA MSA. Charleston, SC MSA. Charleston, WV MSA. Charlotte–Gastonia–Rock Hill, NC–SC MSA. Chattanooga, TN–GA MSA. Chicago, IL PMSA. Cincinnati, OH-KY-IN PMSA. Cleveland, OH PMSA. Columbia, SC MSA. Columbus, GA–AL MSA. Columbus, OH MSA. Corpus Christi, TX MSA. Dallas, TX PMSA. Davenport–Rock Island–Moline, IA–IL MSA. Dayton–Springfield, OH MSA. Decatur, IL MSA. Denver, CO PMSA. Des Moines, IA MSA. Detroit, MI PMSA. Duluth, MN–WI MSA. El Paso, TX MSA. Erie, PA MSA. Evansville, IN–KY MSA. Fall River, MA-RI PMSA. Flint, MI MSA. Fort Wayne, IN MSA. Fresno, CA MSA. Gadsden, AL MSA. Galveston-Texas City, TX PMSA. Grand Rapids, MI MSA. Green Bay, WI MSA. Greensboro–Winston-Salem–High Point, NC MSA. Greenville–Spartanburg, SC MSA. Hamilton-Middletown, OH PMSA. Harrisburg–Lebanon–Carlisle, PA MSA. Hartford, CT PMSA. Houston, TX PMSA. Huntington–Ashland, WV–KY–OH MSA. Indianapolis, IN MSA. Jackson, MI MSA. Jackson, MS MSA. Jacksonville, FL MSA. Johnstown, PA MSA. Kalamazoo, MI MSA. Kansas City, MO–KS MSA. Kenosha, WI PMSA. Knoxville, TN MSA. Lancaster, PA MSA. Lansing–East Lansing, MI MSA. Laredo, TX MSA. Lawrence-Haverhill, MA-NH PMSA. Lexington-Fayette, KY MSA. Lima, OH MSA. Lincoln, NE MSA. Little Rock–North Little Rock, AR MSA. Lorain-Elyria, OH PMSA. Los Angeles-Long Beach, CA PMSA. Louisville, KY–IN MSA. Lowell, MA-NH PMSA. Lubbock, TX MSA. Macon–Warner Robins, GA MSA. Madison, WI MSA. Manchester, NH MSA. Memphis, TN–AR–MS MSA. Miami-Hialeah, FL PMSA. Milwaukee, WI PMSA. Minneapolis–St. Paul, MN–WI MSA. Mobile, AL MSA. Montgomery, AL MSA. Muncie, IN MSA. Nashville, TN MSA. New Bedford, MA MSA. New Britain, CT PMSA. New Haven–Meridien, CT MSA. New Orleans, LA MSA. New York, NY PMSA. Norfolk–Virginia Beach–Newport News, VA MSA. Oklahoma City, OK MSA. Omaha, NE–IA MSA. Orlando, FL MSA. Peoria, IL MSA. Philadelphia, PA-NJ PMSA. Phoenix, AZ MSA. Pittsburgh, PA PMSA. Pittsfield, MA MSA. Portland, ME MSA. Portland, OR PMSA. Providence, RI PMSA. Pueblo, CO MSA. Racine, WI PMSA. Raleigh–Durham, NC MSA. Reading, PA MSA. Richmond–Petersburg, VA MSA. Roanoke, VA MSA. Rochester, NY MSA. Rockford, IL MSA. Sacramento, CA MSA. Saginaw–Bay City–Midland, MI MSA. St. Joseph, MO MSA. St. Louis, MO–IL MSA. Salt Lake City–Ogden, UT MSA. San Angelo, TX MSA. San Antonio, TX MSA. Riverside-San Bernardino, CA PMSA. San Diego, CA MSA. San Francisco, CA PMSA. San Jose, CA PMSA. Savannah, GA MSA. Scranton–Wilkes-Barre, PA MSA. Seattle, WA PMSA. Shreveport, LA MSA. Sioux City, IA–NE MSA. Sioux Falls, SD MSA. South Bend–Mishawaka, IN MSA. Spokane, WA MSA. Springfield, IL MSA. Springfield, MO MSA. Springfield, MA MSA. Stamford, CT PMSA. Stockton, CA MSA. Syracuse, NY MSA. Tacoma, WA PMSA. Tampa–St. Petersburg–Clearwater, FL MSA. Terre Haute, IN MSA. Toledo, OH MSA. Topeka, KS MSA. Trenton, NJ PMSA. Tulsa, OK MSA. Utica–Rome, NY MSA. Waco, TX MSA. Washington, DC–MD–VA MSA (not included for regressions with farm land price data). Waterbury, CT MSA. Waterloo–Cedar Falls, IA MSA. Wheeling, WV–OH MSA. Wichita, KS MSA. Wichita Falls, TX MSA. Wilmington, DE-NJ-MD PMSA. Worcester, MA MSA. York, PA MSA. Youngstown–Warren, OH MSA.

Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
pop	161	896167.2	1283563	79250	8863164
lpop	161	831550.1	1255121	84784	9120346
l2pop	161	746180.6	1327609	71047	1.16E+07
l3pop	161	630855.4	1211201	64630	1.07E+07
l4pop	161	516869.4	1218666	56141	1.29E+07
mdvalde	161	64342.5	39049.81	29303.75	299923.5
lvalue	161	56533.05	18086.76	33373.79	168446.6
l2value	161	43096.59	11885.09	20479.38	129270.6
l3value	161	40267.75	9266.516	16891.89	96621.63
l4value	161	32646.45	7896.348	9037.345	63767.64
mdrntde	161	324.9155	72.07506	212.7008	645.7537
lrent	161	283.3399	33.43498	205.0971	413.835
l2rent	161	266.9367	46.79602	152.0619	417.5258
l3rent	161	231.5973	34.30531	131.7568	331.0811
l4rent	161	169.0212	27.81424	76.30705	251.2448
realfarm	160	1018.723	1000.949	111.7955	5323.752
lrlfrm	160	1400.248	690.4677	203.8798	3220.555
l2rlfrm	160	885.9879	454.3873	163.2989	2180.167
l3rlfrm	160	622.0113	316.0447	92.85788	1452.615
l4rlfrm	160	467.824	232.3587	73.40884	1074.626
density	161	531.7025	705.8572	31.8	7447.6
ldens	161	491.2375	635.0685	29.51999	6601.531
l2dens	161	535.8944	601.4226	22	5419
l3dens	161	575.9503	610.8482	20	4977
l4dens	161	520.9006	581.9254	14	3645

Table 1 - Granger causality regressions
between population and real farm land prices

(1) Dependent Variable: real farmland values		(2) Dependent Variable: population	
first lag farm values	0.0661 (0.1105) not*	first lag population	0.8579 (0.1679) 1%
second lag farm values	2.0997 (0.2163) 1%	second lag population	0.4880 (0.3693) not
third lag farm values	-1.1773 (0.1797) 1%	third lag population	-0.0319 (0.2395) not
fourth lag farm values	0.5057 (0.4173) not	fourth lag population	-0.3914 (0.121) 1%
first lag population	0.0005 (0.0003) not	first lag farm values	-113.1932 (55.8724) 5%
second lag population	-0.0016 (0.0007) 5%	second lag farm values	180.6013 (109.4178) not
third lag population	0.0007 (0.0005) not	third lag farm values	13.2246 (90.9085) not
fourth lag population	0.0005 (0.0002) 5%	fourth lag farm values	-121.9309 (211.0436) not
N	160	N	160
Adj Rsq	0.7741	Adj Rsq	0.9638

F-Test on the four lags of population:	F-Test on the four lags of real farm land values:
$F(4,151) = 2.61$ Prob > F = 0.0378	$F(4,151) = 1.33$ Prob > F = 0.2613

* Significance levels are indicated as 1%, 5%, 10%, or not

Table 2 - Granger causality regressions between population and real farm land prices while controlling for density

(3) Dependent Variable: real farmland values		(4) Dependent Variable: population	
first lag farm values	0.1278 (0.1006) not	first lag population	0.9091 (0.1807) 1%
second lag farm values	1.7270 (0.2029) 1%	second lag population	0.3478 (0.4209) not
third lag farm values	-0.8986 (0.1632) 1%	third lag population	0.1069 (0.2747) not
fourth lag farm values	-0.0733 (0.3706) not	fourth lag population	-0.4825 (0.1388) 1%
first lag population	0.0004 (0.0003) not	first lag farm values	-96.7837 (58.445) 10%
second lag population	-0.0013 (0.0007) 10%	second lag farm values	116.2231 (117.8775) not
third lag population	0.0007 (0.0005) not	third lag farm values	40.1264 (94.8284) not
fourth lag population	0.0000 (0.0002) not	fourth lag farm values	-150.8157 (215.3537) not
first lag density	0.4636 (0.258) 10%	first lag density	130.9225 (149.9275) not
second lag density	0.4564 (0.2767) 10%	second lag density	-46.3348 (160.7837) not
third lag density	-0.3389 (0.2192) not	third lag density	180.2373 (127.3483) not
fourth lag density	0.3148 (0.1451) 5%	fourth lag density	-178.3598 (84.2923) 5%
N	160	N	160
Adj Rsq	0.8304	Adj Rsq	0.9641

F-Test on the four lags of population:

F(4,147) = 9.88
Prob > F = 0

F-Test on the four lags of real farm land values:

F(4,147) = 1.26
Prob > F = 0.2877

Table 3 - Granger causality regressions
between population and real median housing values

(5) Dependent Variable: median housing values		(6) Dependent Variable: population	
first lag housing values	1.1218 (0.1673) 1%	first lag population	0.7309 (0.16) 1%
second lag housing values	2.9371 (0.3969) 1%	second lag population	0.9245 (0.3378) 1%
third lag housing values	-2.9920 (0.5583) 1%	third lag population	-0.2607 (0.2212) not
fourth lag housing values	0.8620 (0.4627) 10%	fourth lag population	-0.5031 (0.1179) 1%
first lag population	-0.0084 (0.012) not	first lag housing values	0.9939 (2.2251) not
second lag population	-0.0272 (0.0254) not	second lag housing values	3.9403 (5.28) not
third lag population	0.0454 (0.0166) 1%	third lag housing values	-1.0338 (7.4266) not
fourth lag population	-0.0056 (0.0089) not	fourth lag housing values	-10.7215 (6.1546) 10%
N	161	N	161
Adj Rsq	0.7836	Adj Rsq	0.9646

F-Test on the four lags of population:	F-Test on four lags of median housing values:
F(4,152) = 3.3 Prob > F = 0.0126	F(4,152) = 1.61 Prob > F = 0.1754

Table 4 - Granger causality regressions
between population and real median housing values
while controlling for density

(7) Dependent Variable: housing values			(8) Dependent Variable: population	
first lag housing values	1.1978 (0.162) 1%		first lag population	0.7698 (0.169) 1%
second lag housing values	1.8388 (0.3919) 1%		second lag population	0.8895 (0.3758) 5%
third lag housing values	-2.2834 (0.5263) 1%		third lag population	-0.2200 (0.2495) not
fourth lag housing values	0.4239 (0.4341) not		fourth lag population	-0.6053 (0.1307) 1%
first lag population	-0.0049 (0.0112) not		first lag housing values	0.9276 (2.4462) not
second lag population	-0.0184 (0.0249) not		second lag housing values	0.2614 (5.9166) not
third lag population	0.0426 (0.0165) 1%		third lag housing values	-0.4491 (7.9466) not
fourth lag population	-0.0296 (0.0087) 1%		fourth lag housing values	-9.3578 (6.5537) not
first lag density	32.1942 (9.9955) 1%		first lag density	121.0293 (150.9084) not
second lag density	7.0249 (10.7351) not		second lag density	38.3921 (162.0736) not
third lag density	4.3721 (8.7397) not		third lag density	122.4218 (131.9486) not
fourth lag density	-7.0044 (5.835) not		fourth lag density	-156.5834 (88.0943) 10%
N	161		N	161
Adj Rsq	0.834		Adj Rsq	0.965

F-Test on the four lags of population:	F-Test on the four lags of housing values:
F(4,148) = 9.09 Prob > F = 0	F(4,148) = 1.53 Prob > F = 0.1972

Table 5 - Granger causality regressions
between population and real median gross rent

(9) Dependent Variable: median gross rent		(10) Dependent Variable: population	
first lag gross rent	1.1363 (0.2065) 1%	first lag population	0.7452 (0.1633) 1%
second lag gross rent	0.9398 (0.2347) 1%	second lag population	0.8394 (0.3435) 1%
third lag gross rent	-0.7297 (0.3078) 5%	third lag population	-0.2180 (0.2282) not
fourth lag gross rent	-0.2031 (0.2449) not	fourth lag population	-0.4747 (0.1198) 1%
first lag population	-0.000061 (0.00003) 5%	first lag gross rent	2261.0420 (1120.495) 5%
second lag population	0.000062 (0.000063) not	second lag gross rent	-1173.9870 (1273.655) not
third lag population	0.000049 (0.000042) not	third lag gross rent	-181.9569 (1669.879) not
fourth lag population	-0.000051 (0.000022) 5%	fourth lag gross rent	-774.0481 (1328.539) not
N	161	N	161
Adj Rsq	0.6159	Adj Rsq	0.9643

F-Test on the four lags of population:

$F(4,152) = 2.44$
Prob > F = 0.0491

F-Test on four lags of median gross rent:

$F(4,152) = 1.37$
Prob > F = 0.2459

Table 6 - Granger causality regressions between population and real median gross rents while controlling for density

(11) Dependent Variable: gross rents			(12) Dependent Variable: population	
first lag gross rent	0.9527 (0.1689) 1%		first lag population	0.7745 (0.1732) 1%
second lag gross rent	0.4176 (0.1988) 5%		second lag population	0.8536 (0.3843) 5%
third lag gross rent	-0.3007 (0.2553) not		third lag population	-0.2263 (0.2608) not
fourth lag gross rent	-0.2908 (0.2007) not		fourth lag population	-0.5519 (0.1299) 1%
first lag population	-0.000038 (0.000026) not		first lag gross rent	1878.2130 (1146.752) 10%
second lag population	0.000098 (0.000057) 10%		second lag gross rent	-1532.2820 (1349.654) not
third lag population	0.000005 (0.000038) not		third lag gross rent	-66.6730 (1733.437) not
fourth lag population	-0.000107 (0.000019) 1%		fourth lag gross rent	-275.2927 (1362.94) not
first lag density	0.0755 (0.0216) 1%		first lag density	74.3259 (146.6426) not
second lag density	0.0358 (0.024) not		second lag density	54.7617 (162.9433) not
third lag density	-0.0159 (0.019) not		third lag density	96.9158 (128.771) not
fourth lag density	0.0001 (0.0127) not		fourth lag density	-168.2271 (86.4047) 5%
N	161		N	161
Adj Rsq	0.7564		Adj Rsq	0.9646
F-Test on the four lags of population: F(4,148) = 13.95 Prob > F = 0			F-Test on the four lags of median gross rent: F(4,148) = 1.1 Prob > F = 0.3587	

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